them and have undergone a similar amount of heat and pressure, especially the former.

One word in conclusion. The reader of Dr. Preller's papers will soon discover that he quotes as if they were authorities of equal value geologists who often express contradictory views. If one man says a group of rocks is late Palæozoic or early Mesozoic, and another that it is Archæan, one of the two must be wrong, so hopelessly that it is no use quoting his opinion. Which of them seems to me to be right will be obvious from what I have written. This expresses opinions not lightly formed. More than thirty years ago I found the views (not of Italian geologists only) so widely discordant that I ceased to study their writings for any other purpose than finding out the position of sections supposed to be critical. From these I have been collecting evidence, by personal examination, visiting, on an average at least once in a year from 1881 to 1911, one or other important district, so as to test repeatedly the hypotheses both of myself and of others. The knowledge thus acquired emboldens me, audacious as it may seem, to express my complete dissent from those geologists who assert the existence of true schists and gneisses of Permian to Liassic age anywhere in the Alpine chain.

NOTICES OF MEMOIRS.

I.—Report of the Joint Discussion on Coal at the Newcastle Meeting of the British Association.

AMONG the more important items in the programme of Section C at Newcastle may be mentioned the discussion with the members of the Chemical Section on "The investigation of the chemical and geological characters of coal, with a view to its most effective utilization as fuel and to the extraction of by-products". The discussion formed a natural and appropriate corollary to the President's address. A desire to abolish the present haphazard methods of utilizing coal—the natural outcome of the backward state of our knowledge of the mineral and its many varieties—was the keynote of the debate; and the desire found immediate expression in the formation of a research committee of Section C to deal with the matter, as well as in the nomination of geological members to serve on the committee of Section B dealing with Fuel Economy.

The discussion was most appropriately opened by Professor G. A. Lebour, who said that the geologist regards coal as a *rock* disposed in layers or seams sandwiched between a roof and a floor of other rocks, and subject to changes in thickness and to interruptions of continuity of various kinds. There are also changes in physical properties and composition, to investigate which he needs the help of others. It is his business to find the coal either by mapping the outcrops or, where there are none, by weighing circumstantial stratigraphical evidence of all sorts. He thus points out the possible extension of known, or the existence of hidden, coalfields. As to the composition of the coal in the seam as a whole, or in the different parts of the seam, he turns to the chemist for information. There is wanted an agreed classification of coals based on both physical and chemical characters. He asked help from the chemists in providing such a classification, with a clear definition of each variety. The value of the analyses provided by the chemists would be greatly enhanced, from the geological point of view, if they could be informed of the nature of roof and floor respectively, since both are factors which undoubtedly influence the composition and properties of the coal between them. It was also very desirable that the analyses should be presented somewhat more uniformly drawn up than is the case at present. For geological purposes an ultimate analysis is of little or no use alone, but should be given together with one of the ordinary commercial kind, in which the percentage of free carbon, volatile matter, and ash is shown. One seam in the Newcastle Coal-field yielded in the north the best household coal, in the centre of its area the best coking coal, and, further south, the best steam coal of the district. He concluded by saying that after fifty years of work at coal he knew less what it really was than he thought he knew at first.

Professor W. A. Bone said he found it difficult to make any very definite statement about the chemical nature of coal, of which we were still largely ignorant. The technical chemist was in the habit of making certain tests with a view to judging the suitability of a given coal for particular economic purposes, and the ultimate composition of the coal substance can be determined with considerable accuracy. But such data, however useful as a guide to the user of coal, gave little or no information as to the chemical structure of coal. Within recent years a good deal of work had been done upon the action of various organic solvents, notably pyridine, upon coal, upon the results of which certain tentative conclusions had been drawn as to two different types of constituents (sometimes termed the 'resinous' and 'cellulosic or humic' types respectively) which are supposed to make up the coal substance, and this seemed to be a promising line of attack upon the problem. But it was too soon yet to put forward anything more certain than a working hypothesis. During the past thirty years a number of eminent chemists had individually attacked the problem of the chemical structure of coal on different lines, but little or nothing had been done to co-ordinate these various researches or to review their results in any active manner. In his opinion no great progress was likely to be made except on the lines of some well-considered scheme of research in which the various workers would find their place and collaborate. The Fuel Economy Committee had the matter in hand, and if the geologists wished to be more largely represented their further valued assistance would be welcomed by the chemists.

Professor Kendall (Leeds University) addressed himself particularly to the question of the nature and origin of the ash in coal-seams, a subject of great economic and geological importance. He recognized three sources of the mineral substances found in coal-seams—first, the residue of the actual mineral constituents of the plants composing the coal; second, detrital mineral matter, generally fine dust or mud, that had been blown or washed into the area of coal-formation; and

https://doi.org/10.1017/S0016756800208339 Published online by Cambridge University Press

third, the sparry substances, generally calcite or iron pyrites, segregated as veins in the seams. The ordinary method of making an analysis for commercial purposes would not, of course, discriminate between these. A certain weight of coal was taken as nearly as possible representative of the whole seam, and after being broken into small particles was sampled and the fraction analysed. This gave no details as to the location of the respective types of ash, observation upon the seam under ground, or of the coal as marketed, nor showed how the sparry material was disposed in the 'cleat' or system of joints traversing bituminous coal. The work done in Newcastle by Dr. Garrett and the late Mr. Burton, who obtained radiographs of slices of coal, promised results of great interest; other means were also available. It is well known that ordinary coal consists of alternating bright and dull layers, and the late Professor A. H. Green obtained separate analyses of these two types, showing that the bright layers yield a very low ash percentage, while the dull charcoal layers may contain a much higher proportion. This has been confirmed by general experience. Another method employed for the purpose of deciding whether a coal would be improved by washing was to crush it down to fine granules, $\frac{1}{16}$ in. in diameter, and separate by specific gravity into moieties respectively of 1·2–1·3 and 1·3–1·4. The former in cases cited proved to be bright and lustrous, and to have an ash content amounting to only one-fifth of that found in the heavier sample, which was of a dull aspect. The inference has been drawn from the very low ash content of anthracite that it was composed of a different assemblage of plants from those producing the more bituminous seams or parts of the same seam. The speaker demurred to this, and pointed out that low ash is not a universal characteristic of anthracites, but also that two features of anthracite seams combined to give a low ash, the dull layers are generally of very small dimensions, and anthracite, the world over, is destitute of 'cleat'. The contention that the sparry infilling of 'cleat' crevices in bituminous coal is derived from the coal, seems contradicted by its composition—the high percentage of calcium carbonate and of iron and low potash in the ash taken as a whole is the reverse of what would be found in any average assemblage of plants, and the speaker would regard the lime and the iron as introduced bp percolation from the measures. It is much to be desired that geologists, chemists, and palæobotanists should combine to make exhaustive studies of a seam from floor to roof, and also to extend their scrutiny to the variations of a given seam from place to place, so that such anomalies could be explained as that of a well-known seam in Yorkshire that in two adjacent pits passes from a 'coking' to a 'non-coking' condition.

Dr. Dunn thought the discussion showed the need of co-operation and collaboration, not only of the chemical workers, as suggested by Dr. Bone, but of geologists and botanists with the chemists. Professor Lebour had blamed the chemists for not furnishing a philosophical classification of coals; but classification depended partly on the purpose to be served by it, and partly on the extent of our knowledge of the things to be classified. Such classifications as had been

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attempted had had in view chiefly the various uses of coal, and had no pretensions to being scientific or philosophical, or indicative of the real nature of various coals; and our knowledge of that nature was so rudimentary and incomplete that no true classification was possible. Analyses of coal, too, had chiefly been made for users of coal, and the form which gave the information needed by one class of user might not be suitable for another; the geologists had hitherto for the most part been able to make use only of such analyses, and hence arose the lack of uniformity spoken of by Professor Lebour. All these analyses dealt with the products of the destruction of coal, not with the substances actually contained in it; though much work had been done in the endeavour to understand the nature of coal, very little progress had been made, and we knew little more than that coal contained two or three substances separable by different solvents, one of which seemed to be intimately connected with the coking properties of coal. The question of the ash of coal, raised by Professor Kendall, was a very important one, especially the separation of the inherent ash, or mineral matter originally contained in the plants from which the coal was derived, from the extraneous mineral matter, and also the distinction between ash irregularly distributed as 'dirt', 'stone', or 'shale' among the coal, and that found minutely subdivided throughout it. Great variations occurred in the composition of the ash; it was usually a complex mixture of silicates, but he had had one sample which was practically a pure china clay, and another which contained over 80 per cent of ferric oxide. Analyses of ash, like those of coal, were usually made by chemists who were unacquainted with the geological features of the occurrence of the coals concerned; and the problems raised by the geologist could never be enlightened by the chemist unless the whole of the circumstances were put before him, and analyses made on the geologist's own samples and for his own purposes. To do this completely, for a survey of all the coal-seams of the kingdom, will involve an enormous amount of labour, and will need not only hearty co-operation between chemists and geologists, but financial assistance on a scale that can hardly be furnished by any other body than the nation.

Professor Bedson dealt briefly with the investigations which had been made into the nature of the organic proximate constituents of coal. He drew attention to the reports of a committee of Section B published in the Transactions of the Association in 1894 and in 1896, and spoke of some of the more recent attempts to isolate the constituents of coal substances by the aid of solvents, amongst which pyridine and quinoline appear to be the most efficient. Although a considerable amount of work has been done, still we are lacking exact information as to the chemical nature of the substances dissolved and the undissolved portions.

Mr. D. Trevor Jones, speaking on behalf of Dr. R. V. Wheeler and himself, and dealing with the question of the constitution of coal from the chemical aspect, remarked that coal is considered to have been formed from decayed vegetable matter by the action of pressure and temperature. The temperature must have fallen short of 300° C. The coal conglomerate can be resolved by means of solvents into

https://doi.org/10.1017/S0016756800208339 Published online by Cambridge University Press

cellulosic and resinic portions. The cellulosic derivatives contain compounds the molecules of which possess the furan structure and yield phenols when destructively distilled. There are also compounds present the molecules of which have structures resembling that of the carbon molecule, but it is unlikely that 'free' carbon is present in coal. The cellulosic derivatives are probably few in type. The resinic derivatives contain compounds in which alkyl, naphthene, and unsaturated hydroaromatic radicles are attached to larger and more complex groupings. It is doubtful whether aromatic groupings are present. Under the influence of pressure the bulk of the resinic derivatives have become highly polymerized. The oxygenated resinic derivatives are chiefly oxides, probably cyclic oxides; esters, lactones, anhydrides, acids, and ketones are absent or present only in small quantity. Hydrocarbons exist in the resinic portion of coal; saturated hydrocarbons (paraffins) are, however, present in small quantities only.

Dr. Marie C. Stopes, who had also been working in conjunction with Dr. Wheeler, said that in dealing with the composition of coal the chemist is faced with the difficulty that there are contained in it a number of different compounds which must be separated from one another before their characters can be determined. The only clue to their composition is the fact (no longer seriously disputable) that they are of vegetable origin. In estimating the nature of coal unaltered by heat or chemical action, up to date the chemist has done no more than, by means of solvents, roughly to separate coal into two main classes of constituents which have been termed 'cellulosic' and 'resinic'. Of these the 'cellulosic' constituents are separable into two groups. Palæobotany has established the fact that some, if not all, ordinary bituminous coals are formed from a mixture of various parts of land-plants.[1] No living plant is so simply divisible into two constituents as is coal into 'cellulosic' and 'resinic'; cellulose forms the major part of the cell-walls of the soft tissues, resin may be present in special cells or glands, and may possibly be modified from various cell contents, but the different portions of even the simplest land-plant are composed of a great variety of distinct chemical compounds, many of which have been named and classified by plant-physiologists. Though a number of these substances may be but slight variations of the 'cellulose' complex molecule, yet in the living plant they have distinctive work to do and have recognizably various morphological and physical properties. It is not unnatural to assume, therefore, that these various substances may be the sources of different chemical compounds now in coal. It will be readily understood that were different by-products from coal traceable to specific parts of plants, and these plant-remains were visually recognizable in the coal itself, a considerable step might be made in our knowledge of coals and their potentialities. For the individual plant portions might be isolated by suitable methods, and the substances for which they were responsible when coal is heated determined. (This is not invalidated by the fact that these portions may or may not differ in composition from the corresponding parts of living plants.) It is on such work that we are at present engaged,

[1] Though this is widely accepted it has been *proved* in very few cases.

using as the starting-point the instance that the phenols obtained when coal is destructively distilled are derived from that particular class of compounds grouped as 'cellulosic'. As plant mechanisms had evolved many distinctive forms of cellulose compounds even by the time of the Carboniferous epoch, we think it is necessary to ascertain whether the various modifications of cellulose differ materially in the compounds they yield, and if so which part of the plant substance corresponds to any particular coal-derivative. An illustration may be useful here: Conspicuous in the construction of many coals are the small yellow bodies known to everyone as spores. Their walls are formed of a derivative of cellulose. Are they, or are they not, still in a condition to react distinctively to treatment by pyridine? Those who have experience in the examination of coals will recognize the practical difficulties in the way of answering so apparently simple a question, for hitherto spores have not been recognizable in lump coal but in thin sections, while, on the other hand, thin sections are not suitable for extraction by pyridine. Nevertheless the difficulties have been overcome, and in the insoluble residue of coal extracted by pyridine we have observed unaltered spores in large numbers. This proves that the particular modification of cellulose forming their walls is one of the 'cellulosic' derivatives insoluble in pyridine. Since some coals are largely composed of spores this fact is of some value, more particularly as spores have a most distinctive appearance and are generally recognizable in thin sections. The next stage in the work is the isolation from coal of a sufficient number of spores to make possible a chemical examination to ascertain what particular type of chemical compounds they yield on destructive distillation. Spores, though the most conspicuous, are by no means the principal constituents of most coals; wood, soft parenchyma, cork, chlorophyll-containing or green tissues of leaves, must all have been universally present in proportions varying from inch to inch in the mass of débris from which any humic coal was formed. Cuticles, morphologically very distinctive portions of plants, and at the same time largely formed of a specific chemical compound to which the name cutin has been given, are conspicuous in the coal substance. We have now isolated sufficient pure cuticles from coal to distil them separately. It will be our business to track down the substances in coal one by one and to isolate them in such a form as will render their chemical examination possible. To hunt this extremely elusive game the microscope is necessary, and the chemist alone is unable to interpret what is to be seen on its field; the palæobotanist alone cannot probe into the chemical composition of even the plant-structures he best recognizes. This is obviously a case for co-operation. The practical aim of such work should be to devise methods whereby satisfactory evidence can be obtained as to the most economic use to which a given seam can be put, coal being regarded not only as a fuel but as the source of innumerable, and some perhaps unsuspected, materials of increasing importance in modern life. The ultimate aim of the research is a complete scientific knowledge of the chemical composition and mode of formation of coal.

Dr. Hickling desired to support all that had been said by the preceding speaker regarding the supreme importance of the closest co-operation between chemical and microscopical investigators of coal-substance, and of both with the work of the field-geologist, if we are to ensure the most intelligent and profitable use of our coal resources. The great importance of the problems involved no one would question, and the experience he had had in their investigation had convinced him that only a considerable body of workers dealing in close co-operation with all branches of the subject could hope to attain in reasonable time to the ends desired. He strongly hoped that this discussion might have such an issue. In one particular he desired to differ slightly from Dr. Stopes; while all agreed that every true coal was a mass of more or less decomposed vegetable material, he was inclined to suspect that, in general, it was the amount and character of the decomposition which determined the quality of the coal, rather than the nature of the original plants. Certainly it would be unwise to assume that any very intimate relationship must exist between the original composition of a given plant-structure, and the composition of the coal-substance into which that structure is now converted. Palæobotanists would remember that the most beautifully preserved plant-tissues consisted almost wholly of calcium carbonate or silica, and similarly in coal itself the original constituents of the cell-walls, etc., may be very extensively replaced by other materials, though the materials in this case are the decomposition products of the plants themselves. He regarded the co-operation of various classes of workers as especially necessary in discriminating the highly complex association of varied materials which entered into the composition of every coal-seam. The field-geologist readily recognized the sharply defined and distinguished 'bright' and 'dull' bands or lenticles of the seam, while the microscopist was able to confirm the important differences between them. But the microscope enabled us to go much further, and to recognize that two samples of 'bright' coal, indistinguishable in the hand-specimen, are nevertheless widely different in minute constitution. The chemist, on the other hand, so far as any attempt at all had been made in the rational selection of material for analysis, had been in the habit of preparing a carefully mixed sample of all parts of the seam to be investigated. The analysis of such a sample, while possessing a certain commercial value, was clearly of the smallest possible value as a clue to the real constitution of any of the varied substances which are grouped together as coal. He was convinced that a scientific understanding of coals, the obvious pre-requisite of their best utilization, could only be attained by the investigation separately of the many distinct elements of seams which the eye and the microscope revealed.

Professor Fearnsides expressed the hope that out of the present discussion would come a recognition by chemists that ultimate analyses of coals are required for purposes other than the mere determination of the equitable selling price of the coal by the truck. He dealt with the subject of coal as a rock genus, within which quite a number of essentially different species have already been distinguished by geologists and others, and asked that chemists should undertake to express these known differences in terms of the chemical constitution of the coals. He thought that all geologists would recognize the importance of the results which have been already obtained by the study of the behaviour of coals when extracted with various solvents. He had himself come up against some of the technical difficulties mentioned in the paper by Drs. Wheeler & Stopes, which invalidate the results which might be expected from the direct extraction of transparent micro-preparations of coal with pyridine or chloroform, but from his own experiments he was led to expect that the methods of the metallographer, applied to cleat surfaces or polished specimens of coal etched with these solvents, may provide the information which is immediately required. He wished to support Dr. Hickling's contention that whenever a chemical analysis of a sound block of coal is undertaken, opportunity should be given for the palæobotanists to ascertain the microscopic structure of a corresponding portion of that same piece of coal. He expressed the opinion that great mutual advantage would accrue if the chemists would co-operate with field-geologists and mine workers in the choosing of the samples of coal which are worthy of analysis. He suggested in particular that one of the directions in which this co-operation between chemists and geologists was most to be desired was to secure a real knowledge of the lateral variations of composition within the individual lenticles of coal, which in sum constitute the wide-spreading beds of rock which are known as coal-seams.

Professor Boyd Dawkins emphasized the point raised by Dr. Hickling that the apparent identity in structure of certain parts of the coal with the cell-structure of the living plant does not necessarily prove that the original tissues of the plants have been preserved. It is a matter of common geological knowledge that very generally in the process of fossilization the original tissues, both of plants and animals, have been replaced atom by atom by carbonate of lime or silica, or even iron pyrites, without the details of structure having been destroyed. Sometimes, as in the case of the deposit of calcite in wooden troughs in coal-pits, the structure of the wood, including the growth-lines and medullary rays, is faithfully reproduced. In specimens in the Manchester Museum the calcite cast of the interior of sea-urchins, from the Coral Rag, has carried the pattern of the test into the very centre, as the mineral slowly filtered through the wall. This point must be considered by the palæobotanists, who are doing their share of work in dealing with the history of coal. In his opinion the greater part, if not the whole, of the organic element in the coal had been subjected to mineral change.

Professor W. S. Boulton (who presided) expressed his gratification at the opportunity for an interchange of ideas among chemists and geologists upon a subject of vital importance to the nation. Already, much valuable research upon the nature and composition of coal had been done, both on the analytical and on the microscopical and palæobotanical side. He felt sure that when the printed records of the discussion were published, they would serve to stimulate to fresh and more vigorous research, and more especially to co-ordinate and mutually assist the work of the chemist and geologist, and so enormously increase the value of our greatest industrial asset.

II.—The Ealing Scientific and Microscopical Society.

The 39th Annual Report, issued October, 1916 (8vo, pp. xiv + 14), contains, in addition to the affairs of the Society, etc., abstracts of lectures given in the past year, viz.: (1) "Coloration in Mollusca," by B. B. Woodward, F.L.S., F.G.S., F.R.M.S.; (2) "Meteorites and Shooting Stars," by Spencer L. Fletcher, F.R.A.S. (see below); (3) "Colour Photography," by Cyril M. Neaves; (4) High Explosives," by George Senter, D.Sc., Ph.D., F.I.C.; (5) "Are the Planets Inhabited?" by E. Walter Maunder, F.R.A.S.

Meteorites and Shooting Stars. By Spencer L. Fletcher, F.R.A.S.

THE ancients have left reports of stones falling from heaven which were treated as being of supernatural origin, until scientific investigation of phenomena began. Until 150 years ago the scientist either doubted the actuality of such falls of stones, or explained them as caused by stones projected by terrestrial forces (such as whirlwinds or volcanic eruptions) or manufactured in the clouds from particles of dust. If a stone was found heated or partly melted the theory was that it had been struck by lightning. Such ideas were negatived by well-attested falls of meteorites, from that at Dijon in 1761, which could not be reconciled with such origins.

Mr. Fletcher showed a number of views of meteorites, photographed from actual meteorites in the Natural History Museum. He explained that they are divided into aerolites, which are of stone; siderolites, which are partly stone and partly metal; and siderites, which are wholly metal (usually iron mixed with nickel). In many cases their fall is accompanied by a flash of light and loud explosions. A single stone may be found or there may be a shower of stones (from bursting), as at Poltusk in 1868. A notable case was the great meteorite which in 1719 was visible from Aberdeen to Paris, and, passing over the length of England, appears to have fallen into the sea. In that instance, besides the bright light and explosions, the tremor of the air was noted by Halley. Another great siderolite fell at Estherville, Iowa, in 1879, from a clear sky (showing that it had no connexion with clouds), and, bursting, scattered fragments over two miles, one weighing 431 pounds. The conclusion is that these lumps of stone and metal travel in outer space with great velocity, and burn away, wholly or partially, by friction, after entering our atmosphere.

They do not become visible until they reach our atmosphere, and have been observed at heights of 70 miles or less. It has been assumed that, at an earlier period of the earth's history, it possessed much larger volcanoes than any now existing, which threw up stones with such force as to conquer gravitation, so that the stones, instead of falling back to the earth, remained travelling in orbits around the sun, re-crossing our own orbit at every revolution. To conquer the earth's gravitation it would be necessary for the fragments to be projected with a velocity of at least seven miles per second. No volcano of the present day possesses sufficient power to do this, and there is no trace of the greater volcanoes which the theory supposes. This does not of itself, however, disprove the theory, as, since the earth's primeval crust was produced, sedimentary strata amounting to many miles in thickness have been formed, and no

https://doi.org/10.1017/S0016756800208339 Published online by Cambridge University Press

trace of the original crust remains. If the theory is applied to the moon, where there is less gravitation, and there undoubtedly were once immense active volcanoes, it accounts well for some of the slower moving meteorites, which may have been travelling round the sun in orbits which intersected our own, since the time when the moon's volcanoes were active.

Their most probable origin is to be found in the primeval nebula, of which the comets are fragments. Comets travel in orbits round the sun, which are longer and narrower than the orbits of the planets. Passing too near a planet, a comet may become captured by its attraction, and have to revolve in a new orbit, which carries it around the sun, and then back to the place where the planet captured it. It thus becomes a short period comet.

When comets first become visible to us they are tailless, but as they approach the sun the tail appears and grows, and is usually repelled by the sun. The heat of the sun drives vapours out of the head of the comet (which consists of a cluster of meteors); the electrons thrown out by the sun condense these vapours into particles so small that they can be repelled by the sun's light against gravitation, thus forming the tail. The tenuous character of the tail is clear from the fact that it does not obscure the stars from our vision.

To sum up the history of these bodies, Mr. Fletcher went back to the nebula, from which all stars are formed. It condenses into a system like our Solar System, but some fragments or wisps are left out, which form the heads of comets and travel round the central sun in long orbits. They are caught by planets and reduced to smaller orbits. The emission of the tail gradually wears them out till they become tailless, and are reduced to streams of meteors. These get in time strewn round their orbits. Then the question arises, are meteorites and shooting stars the same? In general it would seem so, but in that case the meteorites which reach the earth in tangible form must be the very largest shooting stars, as the usual shower of them only produces the finest dust.

III.—Historical Manuscripts Commission: The Early Water Supply of Exeter.

In the *Report on the Records of the City of Exeter*, just issued by the Historical Manuscripts Commission (characterized by the halfpenny Press as "waste of paper"), will be found the following interesting documents relating to the water supply of Exeter City.

"1260. The Prior and Convent of St. Nicholas grant leave to Martin Durling and his heirs to draw water 'ab aqueducto que est in cemeterio nostro ce Occidentali parte ecclesia nostre per gardinum nostrum quod est in occidentali parte que ducit a magno vico usque ad Fratres Minores'."

"1299. Agreement on the part of the Mayor and Commonalty of Exeter by consent of Edmund, Earl of Cornwall, with Henry de Bolleg', Archdeacon of Totnes, concerning the building of a tower next the said Archdeacon's house—'per quam communis aqua civitatis ingreditur.'"

"1346. Settlement of a dispute between the Prior of St. Nicholas on the one side and the Dean and Chapter of the Cathedral and the Mayor, etc., on the other, in regard to the making and repairing of the common water 'conduit', the water of which rises without the East Gate in St. Sidwell's parish."

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"1347. King Edward III grants to the Warden and Convent of the Grey Friars of Exeter 'quod ipsi duos modicos [*sic*] atque ortus se jungentes in profunditate fossati civitatis Exon inter orientalem et australem portas ejusdem civitatis profundius fodere et muro lapideo basso includere et aquam de ortibus illis sive fonte inde facto exinde per fistulam subterraneam in fossato predicto et ultra stratam regiam usque ad domum sive habitacionem fratrum predictorum, qua in loco sicco situatur et ad quam aque cursus non habitur, ponendam ducere ac caput fontis predicti dictamque fistulam quotiens reparacione et emandacione indigent reparare et emendare ac de novo construere et facere prout magis expedire viderint', etc."

"1444. The chamber obtain licence to dig for water in St. Sidwell's Fee and to carry away the water in leaden pipes to the new conduit."

"1534. 'Mdm. that John Newtun and John Geboons beganne to make the grete condet of Exsetur the viij day of Novembre, and here folowyth the costes and charges.' 'Thys ys the hole boke, the sum thereof trewly caste as y can do—xxviij*li.* x*s.* viij*d.*'"

"1600 and 1649. Contracts made to lay new leaden pipes to the conduits and cisterns of the city."

"1694. Contract concerning the waterworks and the supplying of the city with water. And in 1695 the Mayor, etc., make a grant of the waterworks of the city and several parcels of land for a term of 200 years."

The last document brings the matter almost to our own days.

REVIEWS.

I.—Geology and the Panama Canal.

THE United States Department of the Interior (Bureau of Mines) has issued a Bulletin (No. 86) by Donald F. Macdonald on "Some Engineering Problems of the Panama Canal in their relation to Geology and Topography". This extremely interesting publication (price 45 cents) deals with topographic types, climate, streams, valleys, coastal conditions, and their several relations to the works. It discusses the general geology and its connexion with the engineering problems as found in the sedimentary and the igneous masses cut through. Then with the structural geology, folding, faulting, shearing, fissuring, jointing, and intrusions; values of the various rock material for constructive work; stability of foundation rocks and conditions affecting the same; slides, their causes and remedies, with full details of the canal slides and illustrative slides from other areas and their cure; local heating of rock masses by chemical decomposition on weathering, by drilling or blasting; danger from earthquakes or earth-movement, etc. All which matter can be applied to any constructive works according to varying local conditions, and therefore of considerable value in handy octavo form. The pamphlet closes with a tabulation showing the cost per cubic yard of dry excavation, crushed stone, coarse rock, sand, masonry, etc., and provides bibliographies of 'slides' and methods of mining.—C. D. S.

II.—Thicknesses of Strata of the Counties of England and Wales. Memoirs of the Geological Survey. pp. vi + 172. 1916.

UNDER this title the Geological Survey have issued a summary of the chief facts regarding the thicknesses of the newer strata of England and Wales. The authors wisely limit themselves to